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TECHNICAL REPORT

72-23-AD

A DISCUSSION OF THE APPLICABILITY OF PARACHUTES WITH PULLED DOWN VENTS FOR AIRDROP OF SUPPLIES AND EQUIPMENT FROM A 500 FOOT ALTITUDE

by

Edward J. Giebutowski

Research and Advanced Projects Division

October 1971

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

Airdrop Engineering Laboratory

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Project Reference:
1F162203D195

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AIRDROP ENGINEERING LABORATORY
US ARMY NATICK LABORATORIES
NATICK, MASSACHUSETTS 01760

FOREWORD

Considerable emphasis has been placed on the achievement of a low altitude airdrop capability to reduce aircraft vulnerability and improve airdrop accuracy. Several concepts have been, and are, under investigation to determine the best method to achieve such a capability. One of these concepts involves the use of a centerline to pull down the vents of otherwise standard recovery parachutes to decrease inflation time and provide a greater drag area. This report reviews test data from actual flight tests and discusses the resulting performance relative to achievement of a 500 ft airdrop capability. The work was performed as a work unit 013 under Task No. 1F162203D195-01 Exploratory Development of Airdrop Systems - Low Altitude Airdrop System for Supplies and Equipment.

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ABSTRACT

Data from thirty one airdrop tests were plotted to show the variation of vertical, horizontal and total velocities and system orientation angle from the vertical as a function of altitude loss from the launch altitude. The purpose was to determine the applicability of using standard G-11A parachutes modified with pulled down vents for airdrop of Army supplies and equipment from an altitude of 500 feet. It was concluded that the "system second vertical" was the earliest event which could be considered a suitable criterion for acceptable impact conditions of horizontal and vertical velocity and system orientation angle. Configuration of one, two, three, five, six and seven canopies having loadings of approximately 5000 pounds per canopy (a range of unit weights from 5000 to 35,000 pounds) were investigated. It was determined that only the one and two canopy configurations with pulled down vents achieved the "system second vertical" at 500 ft absolute altitude or less, resulting in a very limited potential applicability of the tested system for the above purpose.

Introduction

The purpose of this study is to determine the extent to which the use of pulled down vents in standard G-11A parachutes can be used for reducing the altitude of airdrop operations to 500 feet. The pulled down vent modification involves the use of a centerline between the confluence point of the parachute suspension line system and the vent or apex of the parachute canopy. It has been found that a centerline of 95 feet reduces the filling time of the G-11A canopy and increases the drag area thus providing less altitude loss from the time of aircraft exit to the time when conditions first become acceptable for landing. The 95 foot length was determined to be the optimum length based on a series of full scale drop tests using various length centerlines.

Since there are currently no reliable analytical techniques to evaluate system performance for pulled down vent parachutes, especially when used in clusters, the present analysis is based only on a review of performance data from limited full scale tests. The test data consists of velocity, altitude, and system angle information versus time which was reduced from cinetheodolite position time measurements made during the flight test. The test data was obtained by the US Air Force 6511th Test Group (Parachute) at the Naval Air Facility, El Centro, California under a program identified as LIC 5057 "G-11A Vent Control System".

Discussion

1. Scope

The configurations of interest were those of single parachutes and clustered parachutes of two, three, five, six and seven canopies having canopy loadings of approximately 5000 pounds. This covers an airdrop weight range of unit loads between 5000 and 35,000 pounds which adequately covers the range of weights which need to be airdropped by the Army. As is usual in full scale testing of cargo airdrop systems, only a very few drops have been conducted for each of the various configurations, primarily because of funding and time constraints. Therefore, there are usually not more than three or four test drops for any particular configuration which completely replicate the value of such parameters as release airspeed, canopy loading, reefing line configurations, riser extension length, etc. Table 1 lists the various configurations used in the analysis; system description parameters are shown in the left hand side of the table.

2. Data Reduction

The original tabulations of data as received from the test agency were used to plot velocity and angular displacement as a function of altitude loss i. e., distance below the aircraft launch altitude. The data was plotted at one second intervals over a thirty second period after launch. This was sufficient to include occurrence of a complete oscillation cycle after occurrence of the vertical orientation of the system. Thirty one airdrops were considered and characteristic velocity and angle information was extracted from the plots and tabulated in Table 1.

One typical set of curves for each of the configuration studies are presented in Figures 1 through 6 of Appendix A. These figures are presented to illustrate representative differences in performance between configurations; they would not be taken as absolute indicators of the average performance for each of the configurations.

Four curves are drawn for each test drop; these are vertical velocity (rate of descent), horizontal velocity, total velocity and system angle from the vertical (0^{o}), all plotted against altitude loss on the ordinate. Some discussion of each curve and its salient points will be helpful at this point.

Referring to any of the figures shown in Appendix A, the vertical velocity curve starts out at the "zero altitude loss" level with a value of zero since at this point, the cargo is just exiting the aircraft. Immediately on extraction, the vertical velocity begins to increase. This portion of the curve represents the dominant influence of gravity on the descent rate, since the parachute force is either very low or not effective due to its nearly horizontal direction and early stage of inflation. As the parachute force increases and its direction becomes more vertical, the curve reaches a maximum value. The rate of descent then diminishes and begins to approach its equilibrium rate of descent.

The horizontal velocity curve starts out at the "zero altitude loss" level with a value approximately equal to the aircraft forward velocity. This velocity begins to decay, first under the influence of the extraction parachute force and then further, under the influence of the opening recovery parachutes. It should be noted here that, if all the airdrop

TABLE I.

	System Characteristics							Transient Phase			System First Vertical				First Maximum Backswing					System Second Vertic		
Drop Number	Centerline Length (Feet)	Riser Extension Length (Feet)	Reefing Line Length (Feet)	Number of Reefing Cutters	Reefing Cutter Delay (SEC)	Launch Airspeed (Knots)	Gross Weight (Pounds)	Maximum Vertical Velocity (FPS)	Alt. Loss to First Vertical Velocity Max. (Ft)	Alt. Loss To First Horizontal Velocity Min. (Ft)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)	Vertical Velocity (FPS)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)	Vertical Velocity (FPS)	Maximum Angle from Vertical (Degrees)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)
											Single G11A – No Centerline											
2181	0	0	60	4	2	130	5410	88	240	320	450	45	55	25	510	--	--	--	12	670	18	30
2421	0	0	60	4	2	130	5410	88	300	420	550	35	38	26	620	--	--	--	20	690	10	26
2422	0	0	60	4	2	130	5410	87	250	480	420	5	25	25	500	5	27	25	10	520	--	--
											Single G11A – With Centerline											
1208	96	0	60	2	2	130	5390	75	180	270	320	28	37	20	350	10	24	15	24	410	20	25
1303	96	0	60	2	2	130	5390	80	160	290	380	35	45	22	420	5	25	20	24	490	15	27
1547	98	0	60	2	2	130	5390	77	180	270	330	35	45	22	380	5	20	15	23	420	15	30
1617	95	0	60	2	2	130	5410	82	200	210	320	35	45	26	370	5	20	15	20	410	5	17
1583	98	0	60	2	2	150	5390	70	175	270	320	37	48	32	400	5	20	15	28	470	12	26
1584	98	0	60	2	2	150	5390	80	175	270	310	25	45	35	370	23	26	15	27	420	35	45
1618	95	0	60	2	2	150	5410	82	200	300	350	48	60	30	400	25	27	18	26	480	12	25
1619	95	0	60	2	2	150	5410	75	190	260	340	50	60	22	400	38	45	24	27	460	17	26
											Two G11A – With Centerline											
1781	95	20	60	4	2	130	10,000	88	190	300	390	36	39	25	420	10	20	12	30	500	10	24
1990	95	20	60	4	2	130	10,750	75	160	260	350	38	50	20	400	18	26	16	31	450	30	35

TABLE I. (cont'd)

Drop Number	Centerline Length (Feet)	Riser Extension Length (Feet)	Reefing Line Length (Feet)	Number of Reefing Cutters	Reefing Cutter Delay (SEC)	Launch Airspeed (Knots)	Gross Weight (Pounds)	Transient Phase: Maximum Vertical Velocity (FPS)	Transient Phase: Alt. Loss to First Vertical Velocity Max. (Ft)	Transient Phase: Alt. Loss To First Horizontal Velocity Min. (Ft)	System First Vertical: Altitude Loss (Feet)	System First Vertical: Horizontal Velocity (FPS)	System First Vertical: Total Velocity (FPS)	System First Vertical: Vertical Velocity (FPS)	First Maximum Backswing: Altitude Loss (Feet)	First Maximum Backswing: Horizontal Velocity (FPS)	First Maximum Backswing: Total Velocity (FPS)	First Maximum Backswing: Vertical Velocity (FPS)	First Maximum Backswing: Maximum Angle from Vertical (Degrees)	System Second Vertical: Altitude Loss (Feet)	System Second Vertical: Horizontal Velocity (FPS)	System Second Vertical: Total Velocity (FPS)	System Second Vertical: Vertical Velocity (FPS)
Three G11A – With Centerline																							
2013	95	40	60	4	2	130	15,000	105	270	430	520	31	40	25	600	2	20	19	22	640	2	20	19
2014	95	40	60	4	2	130	16,000	90	210	390	520	39	55	32	600	5	25	22	17	680	15	28	26
2015	95	40	60	4	2	130	16,000	90	400	500	520	30	32	15	520	2	17	14	21	600	16	25	17
2139	95	40	60	4	2	150	16,000	85	190	300	400	48	51	18	420	21	22	4	21	480	15	24	18
2140	95	40	60	4	2	150	15,000	90	170	400	460	32	43	30	520	10	18	16	16	600	18	27	20
Five G11A – With Centerline																							
2401	95	60	60	4	2	130	26,400	95	230	360	480	38	42	18	530	2	16	15	30	620	18	26	19
2490	95	60	60	4	2	130	26,400	100	220	340	500	60	68	24	530	28	32	16	20	640	13	25	22
0078	95	60	60	4	2	130	26,400	110	250	400	520	40	52	25	600	4	23	21	20	680	13	25	22
0267	95	60	60	4	2	130	26,400	90	190	380	500	34	48	24	520	18	20	12	22	630	32	38	20
0633	95	60	60	4	2	130	26,400	90	270	390	490	50	56	25	500	13	17	4	24	550	18	25	15
0426	95	60	40	2	4	130	25,000	110	300	480	630	--	--	--	--	--	--	--	20	--	--	--	-
0487	95	60	40	2	4	150	25,000	105	400	450	690	62	70	27	790	25	32	23	27	900+	–	--	--

TABLE I. (cont'd)

Drop Number	Centerline Length (Feet)	Riser Extension Length (Feet)	Reefing Line Length (Feet)	Number of Reefing Cutters	Reefing Cutter Delay (SEC)	Launch Airspeed (Knots)	Gross Weight (Pounds)	Maximum Vertical Velocity (FPS)	Alt. Loss to First Vertical Velocity Max. (Ft)	Alt. Loss To First Horizontal Velocity Min. (Ft)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)	Vertical Velocity (FPS)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)	Vertical Velocity (FPS)	Maximum Angle from Vertical (Degrees)	Altitude Loss (Feet)	Horizontal Velocity (FPS)	Total Velocity (FPS)	Vertical Velocity (FPS)
	System Characteristics							Transient Phase			System First Vertical				First Maximum Backswing					System Second Vertical			
										Six G11A – With Centerline													
0517	95	60	40	2	4	130	35,000	113	350	680	720	20	25	20	780	--	--	--	--	850	15	27	23
0637	95	80	40	2	4	130	35,000	120	420	670	760	40	--	--	820	15	26	23	37	920	7	26	24
0824	95	80	40	2	4	130	35,000	120	420	680	800	38	53	38	910	10	20	15	41	1000 +	--	--	–
										Seven G11A – With Centerline													
0888	95	120	40	2	4	150	35,000	113	390	600	760	42	53	25	810	13	18	14	39	910	25	30	20

motion were in a single vertical plane, the horizontal velocity would diminish to zero and start increasing negatively to a maximum value, after which time it would alternate between positive and negative maximums according to the oscillation frequency of the system. The curve which is plotted in the presented figures shows only absolute values of the horizontal velocity i.e., the negative portions of the curve appear as positive values. It may also be noted that the horizontal velocity curve passes through what appear to be minimum velocity points. These are actually points which are in the vicinity of the point where the velocity changes sign, i.e. they are in the vicinity of the zero velocity points which would occur if the motion was truly two dimensional. The reasons that zero velocity points were not located were (a) the motion was really three dimensional so that there may have been some residual out-of-plane component which would preclude the occurrence of a definite zero point, (b) the regular increment (1 sec) at which values were read from the data was too coarse to permit identification of zero velocity points and (c) measurement and data reduction errors. The mimimum points which appear on the curves are, therefore, approximations of the point where the velocity actually changes sign. The possibility of a significant error in altitude exists only at the first minimum point because the velocity is still changing rapidly between data points. Succeeding minimums occur in the region where velocity is changing less rapidly because the system is approaching equilibrium conditions. The magnitude of error in the velocity data due to measurement and data reduction techniques was assumed to be small and constant for the purpose of this study; therefore the percentage of error was considered to be small at the minimum velocity points and negligible at the maximum velocity points.

The total velocity curve is defined as the vector sum of the vertical and horizontal velocity components versus altitude loss. It is also plotted in absolute values.

The system angle vs altitude loss curve plots the angle between the axis of the parachute cargo system and the vertical axis. Again absolute values are plotted and the same discussion which was given above for the behavior of the horizontal velocity curve is pertinent to the sign and values of the system angle. The system starts out at 90 degrees from the vertical, decreases to 0^{o} degrees at the first vertical orientation of the system and then oscillates according to the oscillation frequency of the system.

3. Analysis

In trying to analytically determine whether platform mounted cargo will land satisfactorily when airdropped from a minimum desired altitude, it is necessary to establish or select performance criteria which must be satisfied just prior to impact. The three basic parameters which will be discussed here are vertical velocity (rate of descent), horizontal velocity and angular orientation. For Army airdrop operations the ideal conditions for impact would be, (a) a rate of descent compatible with efficient cushioning requirements, (b) a zero horizontal velocity and (c) a flat impact with the parachute directly above the cargo platform. The motions of a descending parachute system are such that these three conditions are not likely to occur simultaneously.

Before low altitude operations became an active goal of Army airdrop research and development, the only criterion for acceptable landing conditions was that the rate of descent be a nominal 25 feet per second or less. Airdrops were conducted from 1100 to 1500 feet altitudes which permitted enough time for damping of oscillatory motions to non-critical levels before impact. Since low altitude operations will reduce the time available for damping, it is important to consider how the horizontal velocity of an airdrop cargo varies with altitude loss and angular orientation of the system.

Referring now to the figures in the Appendix, it is seen that the first minimum (Point A) in horizontal velocity occurs before the system has attained a vertical orientation for the first time and, before the vertical has been reduced to at least 25 feet per second. This means that the first horizontal velocity minimum point is not a suitable criterion for determining the minimum acceptable altitude for airdrop.

Moving further on the horizontal velocity curve, it is noted that a maximum point occurs which is coincident with the first minimum point (Point B) in the "system vertical angle" curve. This represents the "system first vertical". (The coincidence of a maximum horizontal velocity point with the vertical orientation of a parachute system is analagous to the maximum horizontal velocity of a simple pendulum when it swings through the vertical). From Table 1 it may be seen that, for launch speeds of 130 knots, the vertical velocity readings for most configurations are reasonably close to 25 feet per second. In general, however, the horizontal velocity readings are considerably higher than 25 feet per second. On this basis, the "system first vertical" may be rejected as a suitable criterion for determining minimum acceptable altitude. It is interesting to note that the system first vertical occurs within 520 feet altitude loss for all pulled down vent configurations from one to five canopies when 60 foot reefing lines and reefing line cutters with a two second delay are used. Extensive parachute damage was experienced with the five canopy configurations and subsequent drops were made with 40 foot reefing lines and four second delay cutters. As can be seen from Table 1, this had the effect of degrading the performance to the extent that the rates of descent did not approach 25 feet per second until well after 500 feet of altitude loss had been experienced. Based on the above discussion, it is concluded that cargoes weighing more than 25,000 pounds and requiring five or more G-11A parachutes with pulled down vents are unsuitable for airdrop from 500 feet altitude.

It also appears that the three canopy configuration with pulled down vent is unsuitable for airdrop operations from 500 feet. The drops which were launched at 130 knots experienced an altitude loss of 500 - 520 feet to the "system first vertical" which was determined to be an unsuitable criterion because of the high horizontal velocities. Although the drops launched at 150 knots reach the "system first vertical" before 500 feet of altitude loss has occurred, there is insufficient data to conclude that acceptable horizontal velocity conditions can be achieved within 500 feet. The validity of the data from drop number 2139 which indicates that the system reaches "first vertical" at 400 feet is questionable on the basis of the low rate of descent of 4 fps indicated in the tabulation under "First Maximum Backswing" in Table 1. This is a large deviation from other rates of descent measured at this point and it indicates an unusual behavior of the airdrop system which should be discounted for the present purpose.

The only configurations that reach "system first vertical" well within 500 feet of altitude loss are the one and two canopy configurations having pulled down vents. Since the horizontal velocities at this point are also high for these two configurations, another criterion must be found which simultaneously satisfies the 500 foot altitude requirement and optimizes the impact conditions. The possible criteria are (a) occurrence of "first maximum backswing" (Point C) within 500 feet and (b) occurrence of the "system second vertical" (Point D) within 500 feet. The backswing criterion appears reasonable since it coincides with the second minimum point in the horizontal velocity of a simple pendulum at its maximum angle of rotation.) The "system second vertical" criterion appears reasonable because it optimizes platform attitude and because the damping of the system has reduced the horizontal velocity to levels below that of the "system first vertical". Under the "first maximum backswing" heading of Table 1 it can be seen that most of the horizontal velocities are considerably lower than those which were present at "system first vertical". (There are some exceptions, notably in the case of the single canopy drops which were launched at 150 knots.) However, it will also be noted that the occurrence of the "first maximum backswing" is characterized by angular orientations of the system which might result in platform impact angles of 20 to 30 degrees. Since there is insufficient knowledge of the effects of such impact angles on the great variety of airdroppable Army equipment and vehicles it is considered prudent, at this time, to also reject "first maximum backswing" as a criterion for determining minimum airdrop attitude. The cost of rejecting this criterion in terms of altitude loss appears to be between 40 and 80 feet, which is the difference in altitude loss between "first maximum backswing" and "system second vertical".

From Table 1, it appears that the "system second vertical" is the earliest event which can be considered as the criterion for acceptable impact conditions for one and two canopy pulled down vent configurations dropped from 500 ft absolute altitude. (The contribution of the pulled down vent may be seen by comparing the altitudes to "second vertical" of the single parachute configurations with and without centerlines). It can be seen that the horizontal velocities have been reduced to levels which are in most cases lower than the vertical velocities. There is insufficient data to establish any definite conclusions about the mean horizontal velocity and its variances at the occurrence of the system second vertical or to determine the significance of the two tests which show a considerably higher horizontal velocity at the second vertical (Drop Nos. 1584 and 1990). Based on the data under consideration one can only note that (a) the system second vertical is characterized by acceptable vertical velocities, generally lower horizontal velocities and favorable system orientation angles for pulled down vent configurations of one thru six canopies and (b) that the system second vertical occurs at or below 500 feet of absolute loss for the one and two canopy configurations with pulled down vents. This is illustrated in Figure 1, which shows the range of altitude loss to the system "second vertical" for all the canopy configurations utilizing 2 second delay reefing line cutters. Configurations using 4 second delay cutters (5 thru 7 canopies) were omitted since the altitude loss to the "second vertical" was greater than 800 feet.

4. Conclusions

a. The "system second vertical" was the earliest event which could be considered an indicator of acceptable impact conditions. The "system second vertical" was characterized by acceptable rates of descent and simultaneous occurrence of favorable system orientation angles with horizontal velocities which in most cases were lower than the rates of descent. It may be noted that, with a few exceptions, the horizontal velocities were less than 20 feet per second. The reason for the occurrence of a few excessive horizontal velocity values has not been determined. A possible reason is that the addition of a centerline produces a greater variance in the opening characteristics of a parachute than the usual variance of an unmodified parachute. Evidence of this is indicated in report no. AFFDL-TR-71-15 titled "Model Studies of Inflation Uniformity of Clustered Parachutes" by H. G. Heinrich, R. A. Noreen and R. H. Monohan of the University of Minnesota, February 1971.

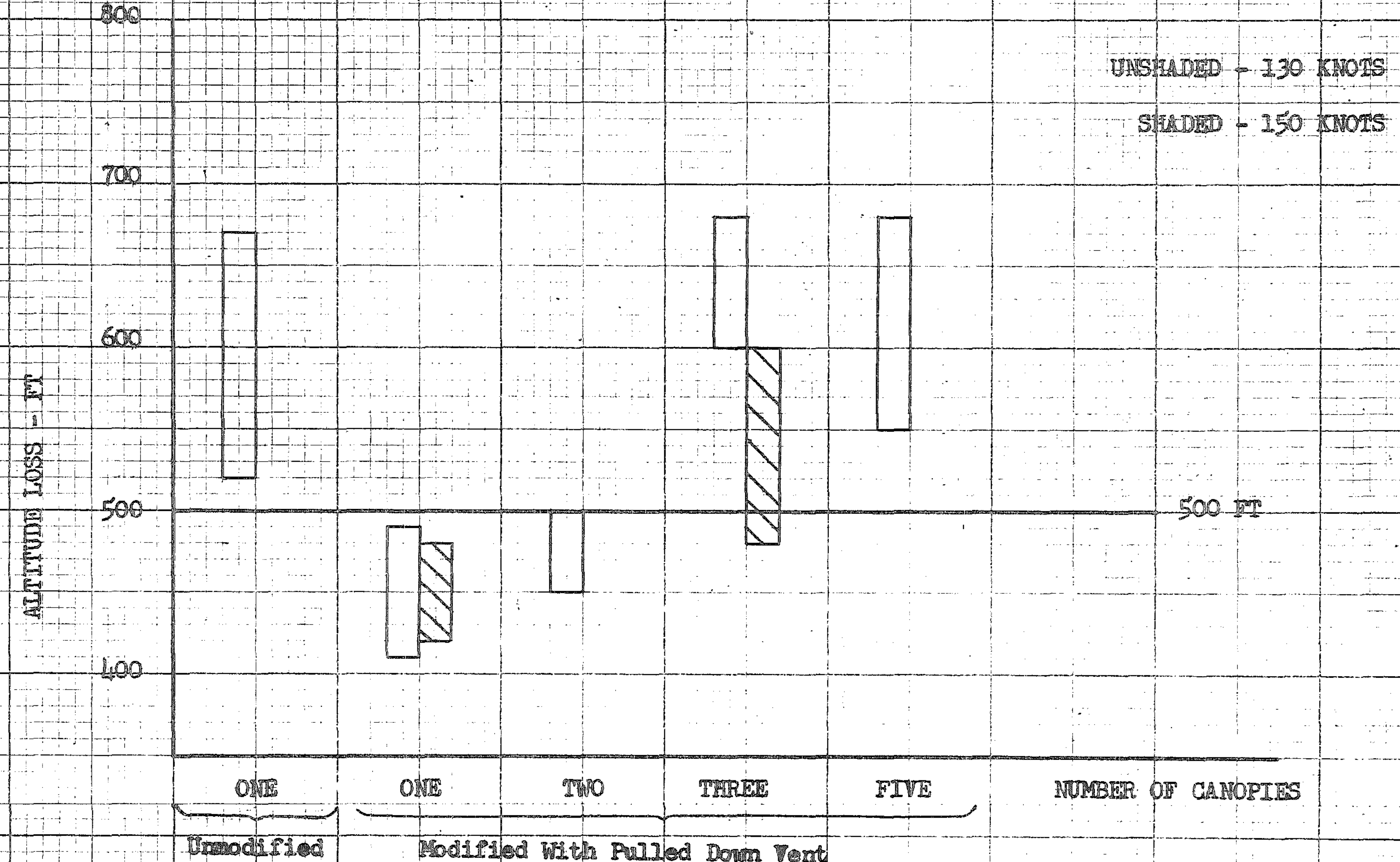
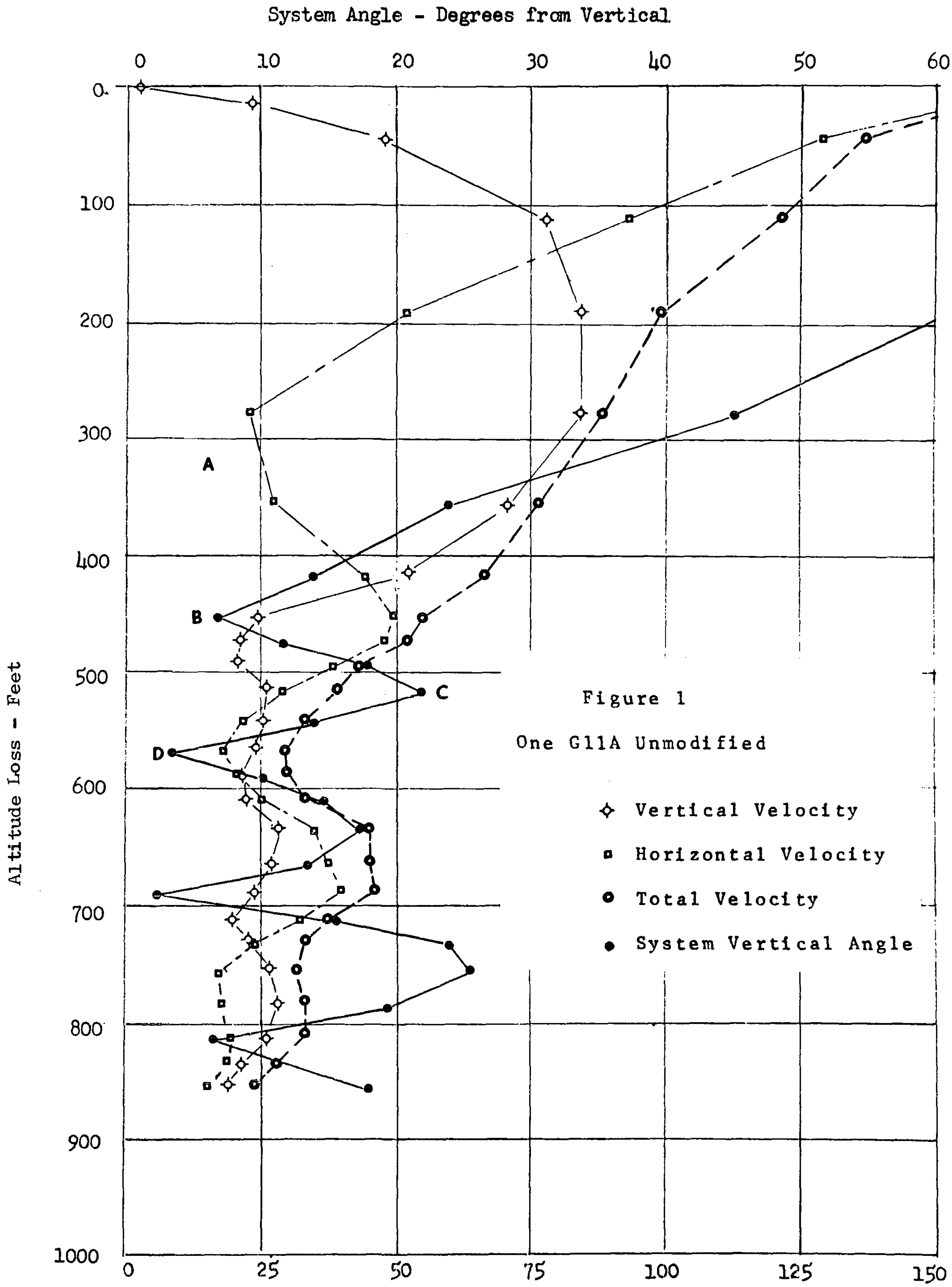


Figure 1. Range of Altitude Loss to System Second Vertical
vs
Number of Canopies

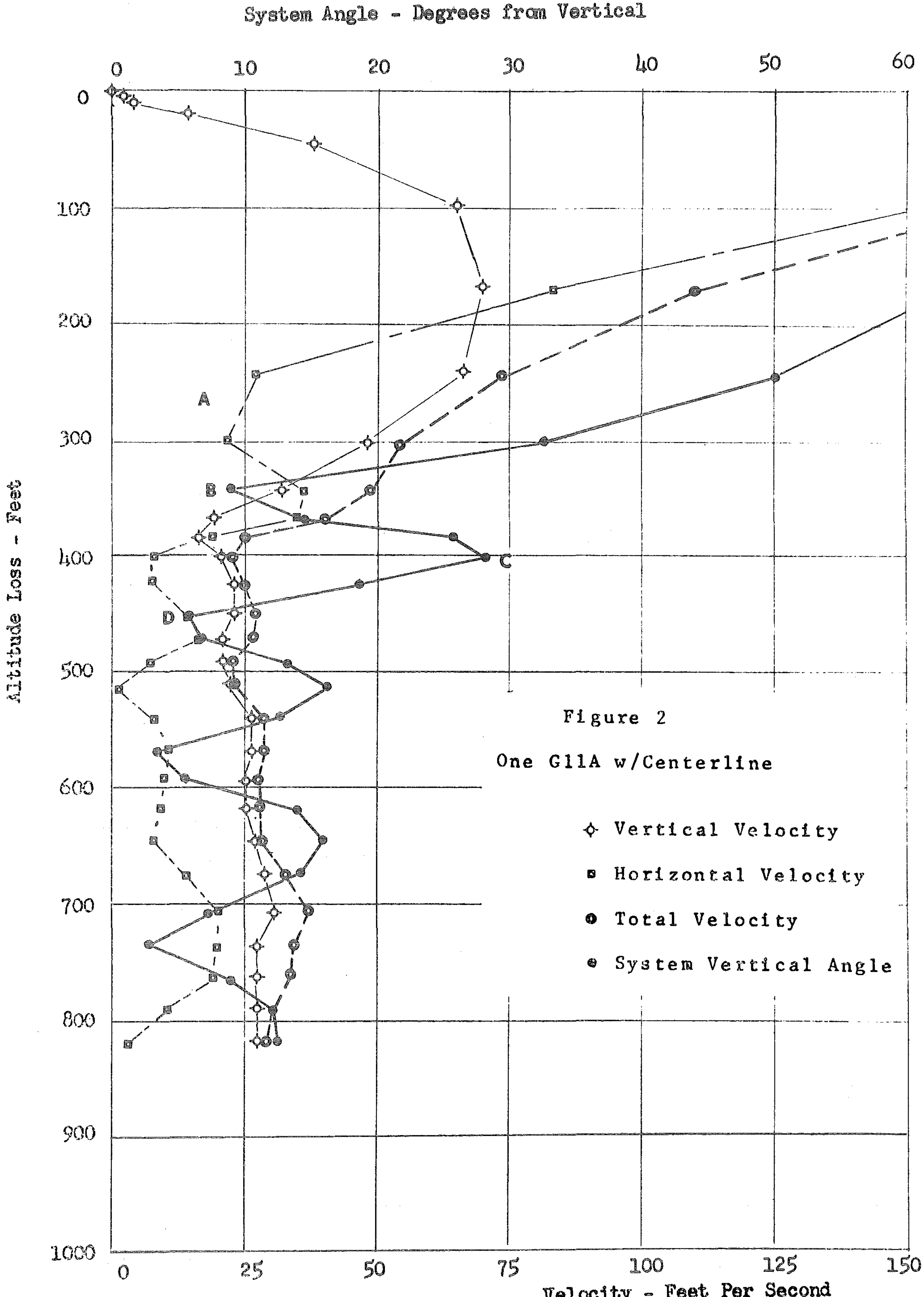
b. The "system second vertical" occured at 500 feet or less absolute altitude loss only for the cases of one and two parachute configurations with pulled down vents. It is, therefore, concluded that the pulled down vent system, as tested, has very limited application for airdrop of Army platform loads from 500 ft altitudes.

c. Further studies are needed to establish upper limits of horizontal velocity and system orientation angle which can be tolerated by Army platform loads at impact. Until these limits are determined with reasonable confidence through analysis and full scale tests, the criteria for determining acceptable impact conditions will remain uncertain.

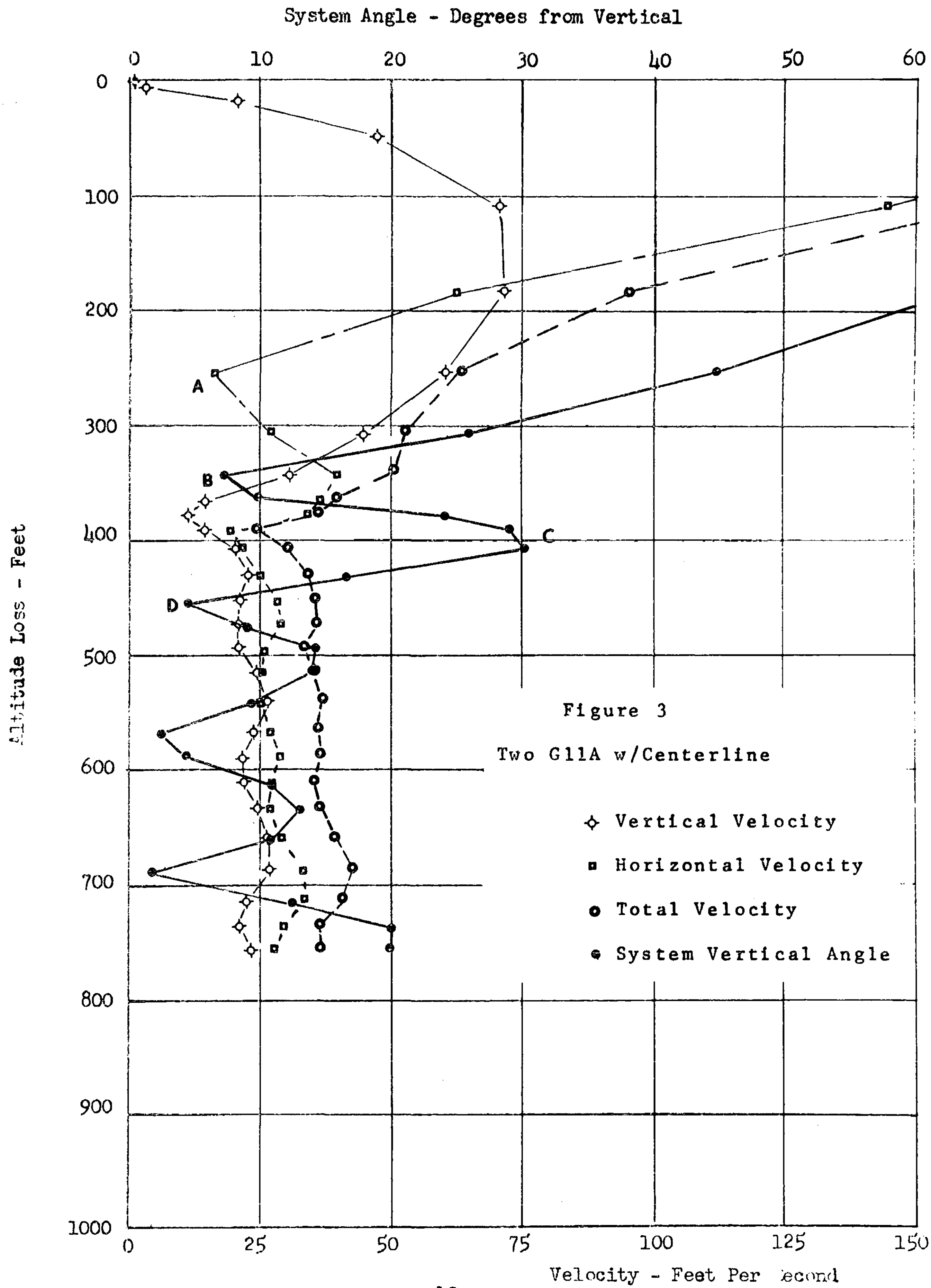
APPENDIX


System Angle - Degrees from Vertical
0
10
20
30
40
50
60
Altitude Loss - Feet
0
100
200
300
400
500
600
700
800
900
1000
A
B
C
D
Figure 1
One G11A Unmodified
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
0
25
50
75
100
125
150
Velocity - Feet per second

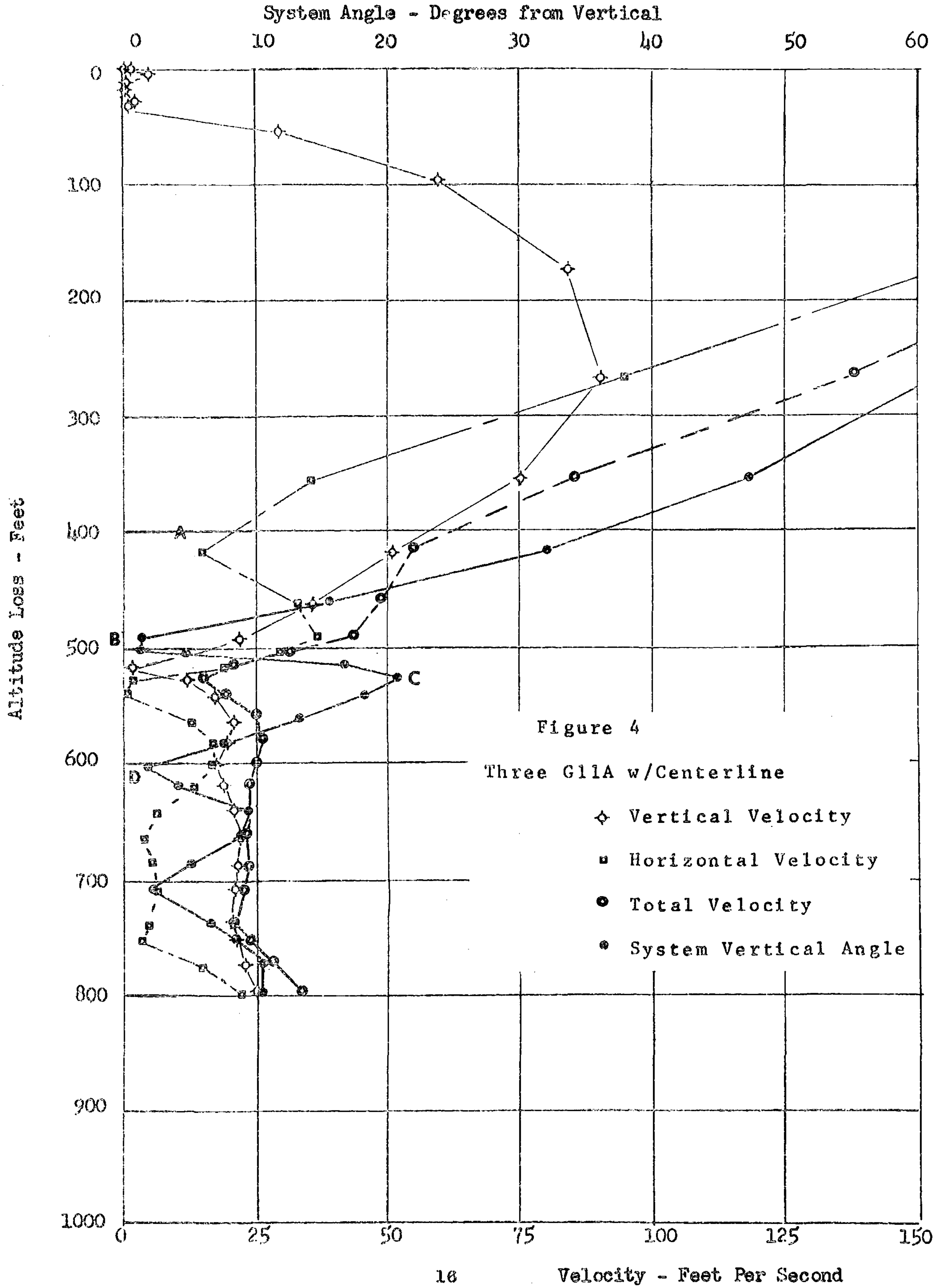
Drop No. 1583


System Angle - Degrees from Vertical
0
10
20
30
40
50
60
Altitude Loss - Feet
0
100
200
300
400
500
600
700
800
900
1000
A
B
C
D
Figure 2
One G11A w/Centerline
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
0
25
50
75
100
125
150
Velocity - Feet Per Second

Drop No. 1990

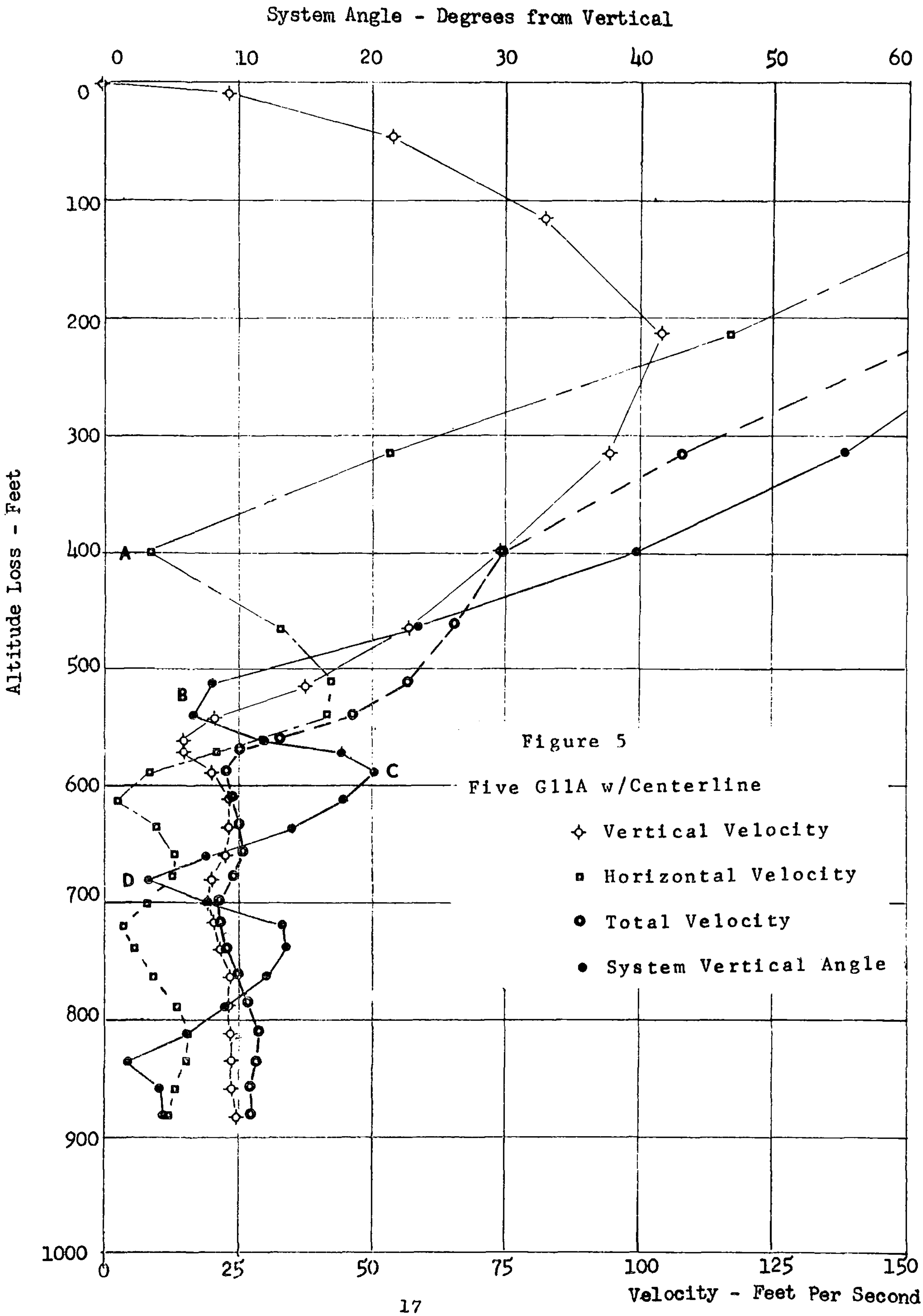

System Angle - Degrees from Vertical
0
10
20
30
40
50
60
0
100
200
300
400
500
600
700
800
900
1000
Altitude Loss - Feet
A
B
C
D
Figure 3
Two G11A w/Centerline
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
0
25
50
75
100
125
150
Velocity - Feet Per Second

Drop No. 2015



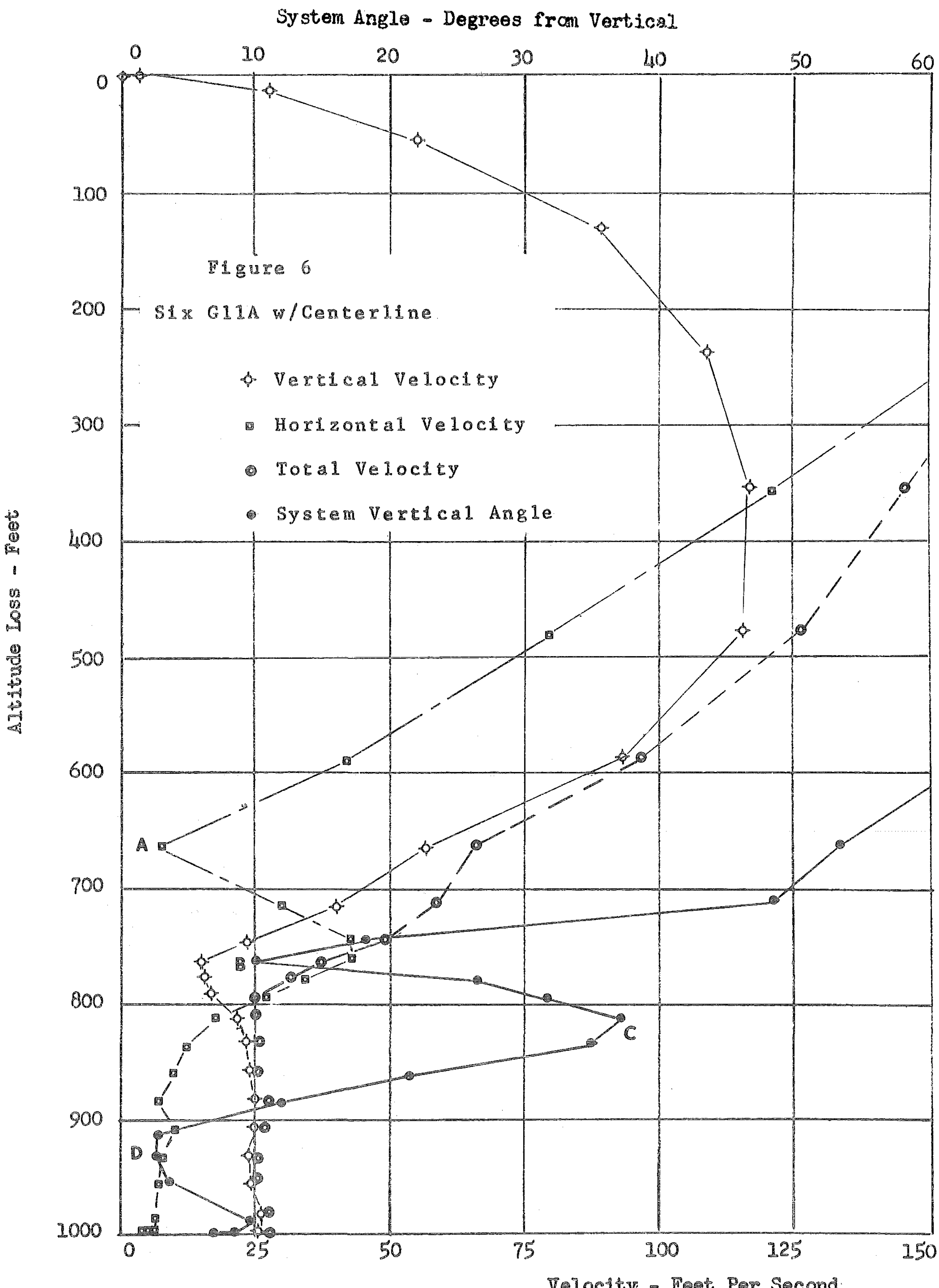
System Angle - Degrees from Vertical
0
10
20
30
40
50
60
Altitude Loss - Feet
0
100
200
300
400
500
600
700
800
900
1000
A
B
C
D
Figure 4
Three G11A w/Centerline
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
0
25
50
75
100
125
150
Velocity - Feet Per Second

Drop No. 0078



System Angle - Degrees from Vertical
0
10
20
30
40
50
60
Altitude Loss - Feet
0
100
200
300
400
500
600
700
800
900
1000
A
B
C
D
Figure 5
Five G11A w/Centerline
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
0
25
50
75
100
125
150
Velocity - Feet Per Second

Drop No. 0637



System Angle - Degrees from Vertical
0
10
20
30
40
50
60
Figure 6
Six G11A w/Centerline
Vertical Velocity
Horizontal Velocity
Total Velocity
System Vertical Angle
A
B
C
D
Altitude Loss - Feet
0
100
200
300
400
500
600
700
800
900
1000
0
25
50
75
100
125
150
Velocity - Feet Per Second

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13. ABSTRACT

Data from thirty one airdrop tests were plotted to show the variation of vertical, horizontal and total velocities and system orientation angle from the vertical as a function of altitude loss from the launch altitude. The purpose was to determine the applicability of using standard G-11A parachutes modified with pulled down vents for airdrop of Army supplies and equipment from an altitude of 500 feet. It was concluded that the "system second vertical" was the earliest event which could be considered a suitable criterion for acceptable impact conditions of horizontal and vertical velocity and system orientation angle. Configuration of one, two, three, five, six and seven canopies having loadings of approximately 500 pounds per canopy (a range of unit weights from 5000 to 35,000 pounds) were investigated. It was determined that only the one and two canopy configurations with pulled down vents achieved the "system second vertical" at 500 ft absolute altitude or less, resulting in a very limited potential applicability of the tested system for the above purpose.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aerial delivery	8		7			
Materiel	1		7			
Parachutes	10		10			
Pulled down vents	10		6			
Vents	10		6			
Air drop operations	4		4			